TITLE OF THE INVENTION

LIGHT EMITTING DEVICE

CROSS-REFERENCES TO RELATED APPLICATIONS

This application is related to Japanese Patent Application No. 2002-291455 filed on October 3, 2002, whose priory is claimed under 35 USC § 119, the disclosure of which is incorporated by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a light emitting device and, particularly, to a light emitting device employing a semiconductor laser chip.

2. Description of the Related Art

A light source is conventionally known, which is adapted to generate white light by exciting a fluorescent material contained in a transparent resin by a light emitting diode (LED) (see, for example, Japanese Patent No.2927279 (0017)-(0018)).

In recent years, such light sources employing a LED have been employed instead of conventional light bulbs for traffic lights and indicators on instrument panels. Further, the light sources have been employed for domestic lighting apparatuses (e.g., desk lights).

A LED chip generally has an output capacity of several milliwatts to 10mW at the maximum and, hence, has difficulty in providing a high output. On the other hand, a semiconductor

laser chip has a higher output capacity on the order of 30 to 50mW. However, the semiconductor laser chip emits a highly coherent light beam with even phases and, hence, is deleterious to human eyes. Therefore, it is difficult to employ the semiconductor laser chip as an ordinary light source.

SUMMARY OF THE INVENTION

In view of the foregoing, the present invention is directed to a light emitting device which employs a semiconductor laser chip and is capable of outputting light having a reduced coherence for use as an ordinary light source.

According to the present invention, there is provided a light emitting device, which comprises: a semiconductor laser chip which emits a laser beam; a coherence reducing member which receives the laser beam and reduces coherence of the laser beam to generate a lower coherence light beam; and a package which houses the laser chip and the coherence reducing member, the package having an opening; wherein the laser beam emitted from the laser chip is converted into a lower coherence light beam by the coherence reducing member, and the lower coherence light beam is outputted through the opening.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a top view of a light emitting device according to a first embodiment of the present invention;

Fig. 2 is a sectional view of the light emitting device as seen in an arrow direction A-A in Fig. 1;

Fig. 3 is a top view of a light emitting device according to a second embodiment of the present invention;

Fig. 4 is a sectional view of the light emitting device as seen in an arrow direction D-D in Fig. 3;

Fig. 5 is a top view of a light emitting device according to a third embodiment of the present invention;

Fig. 6 is a sectional view of the light emitting device as seen in an arrow direction D-D in Fig. 5;

Fig. 7 is a vertical sectional view of a light emitting device according to a fourth embodiment of the present invention;

Fig. 8 is a top view of a light emitting device according to a fifth embodiment of the present invention; and

Fig. 9 is a sectional view of the light emitting device as seen in an arrow direction F-F in Fig. 8.

DETAILED DESCRIPTION OF THE INVENTION

A light emitting device according to the present invention comprises: a semiconductor laser chip which emits a laser beam; a coherence reducing member which receives the laser beam and reduces coherence of the laser beam to generate a lower coherence light beam; and a package which houses the laser chip and the coherence reducing member, the package having an opening; wherein the laser beam emitted from the laser chip is converted into a lower coherence light beam by the coherence reducing member, and the lower coherence light beam is outputted through the opening.

In the present invention, the coherence reducing member may be composed of a fluorescent material which is excited by the laser beam emitted from the semiconductor laser chip to generate fluorescent light having a greater wavelength than the laser beam. The fluorescent light is non-coherent. In this case, the fluorescent material comprises a base, an activator and a flux. The base may be selected from the group consisting of inorganic fluorescent materials including oxides, sulfides, silicates and vanadates of rare earth elements such as zinc, cadmium, magnesium, silicon and yttrium, and organic fluorescent materials such as fluorescein, Eosine and oils (mineral oils). The activator is selected from the group consisting of silver, copper, manganese, chromium, europium, zinc, aluminum, lead, phosphorus, arsenic and gold. The flux is selected from the group consisting of sodium chloride, potassium chloride, magnesium carbonate and barium chloride.

In the present invention, the semiconductor laser chip may be a chip which emits a purple-blue laser beam, and the coherence reducing member may be a fluorescent layer which is excited by the purple-blue laser beam to generate white light.

The purple-blue laser beam herein means a laser beam having a wavelength of 360 to 480nm. The fluorescent layer which is exited by the laser beam to generate the white light is preferably composed of a cerium-activated yttrium-aluminum-garnet fluorescent material, for example,

$Y_3Al_5O_{12}:Ce$, $Y_3(Al_{0.6}Ga_{0.4})_5O_{12}:Ce$ or $Y_3(Al_{0.5}Ga_{0.5})_5O_{12}:Ce$.

The coherence reducing member may be a reflective member having a reflective surface roughened for reflecting the laser beam incident thereon in an unevenly phase-shifted manner. In this case, the reflective member may have a satin-finished reflective surface, for example, a reflective metal surface such as of aluminum finely roughened by polishing or etching, or a reflective resin surface roughened by coarsely depositing a metal thereon.

The roughened reflective surface preferably has a roughness such that a level difference of undulations thereof is several times to several tens times the wavelength of the incident laser beam. Thus, the uneven phase shift of the incident laser beam is efficiently achieved, whereby the coherence of the incident laser beam is reduced or lost.

The semiconductor laser chip may be a laser chip of end light emission type which emits the purple-blue laser beam in two directions parallel to a PN junction plane thereof, or a laser chip of face light emission type.

In the present invention, the package may have a positive electrode terminal and a negative electrode terminal for applying a DC voltage to the semiconductor laser chip. The package may include a metal block for dissipating heat generated by the semiconductor laser chip. The semiconductor laser chip may comprise at least one of three laser chips which emit red, green

and blue light beams, respectively.

The package may include a light transmissive plate fitted in the opening thereof. In this case, the light transmissive plate may have a concave or convex lens function for converging or diverging the light outputted from the package. The light transmissive plate may comprise a fluorescent material. The coherence reducing member may comprise a fluorescent member for converting the laser beam emitted from the laser chip into fluorescent light, and a reflective member for reflecting the fluorescent light emitted from the fluorescent member toward the opening.

With reference to the attached drawings, the present invention will hereinafter be described by way of embodiments thereof. It should be understood that the present invention be not limited to these embodiments.

First embodiment

Fig. 1 is a top view of a light emitting device according to a first embodiment of the present invention, and Fig. 2 is a sectional view of the light emitting device as seen in an arrow direction A-A in Fig. 1.

As shown, a package 1 includes a side wall portion 2 and a metal bottom portion 3. A semiconductor laser chip 4 of end light emission type is disposed on the bottom portion (stem) 3 with the intervention of a metal mount 5 in a generally central portion of the package 1. The laser chip 4 is adapted to emit laser beams

L1, L2 having a wavelength of 350 to 480nm in two directions parallel to a PN junction plane thereof. The side wall portion 2 has a concave inside shape as seen in section in Fig. 2, and a fluorescent layer 6 is provided on the interior surface of the side wall portion 2. Further, a top opening of the side wall portion 2 is closed by a light transmissive protective plate 7.

Two metal rod terminals 8, 9 are provided vertically in the bottom portion 3. The metal terminal 8 is directly connected to the bottom portion 3. The metal terminal 9 extends through the bottom portion 3, and an insulative member 10 intervenes between the metal terminal 9 and the bottom portion 3. The metal terminal 8 is electrically connected to an n-electrode of the laser chip 4 via the bottom portion 3 and the mount 5, while the metal terminal 9 is electrically connected to a p-electrode of the laser chip 4 via a fine metal wire 11. A wire of gold, platinum or aluminum having a diameter of about 30μm is employed as the fine metal wire 11.

The side wall portion 2 is composed of a polyimide resin, and the protective plate 7 is composed of an epoxy resin. The fluorescent layer 6 is composed of an yttrium-aluminum-garnet fluorescent material. The inside of the package closed by the protective plate 7 may be evacuated to vacuum as required.

When a predetermined driving voltage is applied between the metal terminals 8 and 9, the laser beams L1, L2 are emitted from the laser chip 4. The laser beams L1, L2 impinge on the

fluorescent layer 6 to excite the fluorescent layer 6. Thus, non-coherent white light having a light emission peak at a wavelength of about 500nm to about 600nm is generated, and outputted in arrow directions B, C from the package 1.

Therefore, the fluorescent layer 6 is preferably dimensioned and configured so as to sufficiently receive the laser beams L1, L2, efficiently convert the received laser beams L1, l2 into the white light and effectively output the white light from the package 1.

The laser beams L1, L2 may include light components reflected on the fluorescent layer 6 and outputted from the package 1 as they are. In such a case, a fluorescent material is preliminarily contained in the protective plate 7, so that the fluorescent material is excited by the light component. Thus, the laser beams L1, L2 are prevented from being outputted from the package 1 as they are. The same material as for the fluorescent layer 6 may be employed as the fluorescent material for the protective plate 7.

Second embodiment

Fig. 3 is a top view of a light emitting device according to a second embodiment of the present invention, and Fig. 4 is a sectional view of the light emitting device as seen in an arrow direction D-D in Fig. 3.

As shown, this embodiment is provided by partly modifying the first embodiment. That is, the package 1 is

replaced with a package 1a. More specifically, the light emitting device of the second embodiment has substantially the same construction as that of the first embodiment, except that the fluorescent layer 6, the bottom portion 3 and the metal terminals 8, 9 in the first embodiment are replaced with a reflective layer 6a, an insulative substrate 3a and metal interconnection patterns 8a, 9a, respectively.

The reflective layer 6a is formed as having a satin-finished surface by depositing aluminum on the interior surface of the side wall portion 2. The reflective layer 6a has a surface roughness such that the average level difference of undulations thereof is about ten times the wavelength of the laser beams L1, L2, i.e., about 5μm.

When a predetermined driving voltage is applied between the interconnection patterns 8a and 9a, the laser beams L1, L2 emitted from the laser chip 4 are irregularly reflected on the reflective layer 6a thereby to be converted into non-coherent light with uneven phases. Then, the non-coherent light is outputted in arrow directions B, C from the package 1a.

In this embodiment, the laser chip 4 may be adapted to emit light beams having any wavelength within a spectral range from purple to red. The surface roughness of the reflective layer 6a should be adjusted optimally depending on the wavelength.

<u>Third embodiment</u>

Figs. 5 and 6 illustrate a third embodiment of the present

invention, and correspond to Figs. 3 and 4, respectively, which illustrate the second embodiment. A light emitting device of the third embodiment has substantially the same construction as that of the second embodiment, except that the metal mount 5 and the metal pattern 8a in the second embodiment are replaced with a metal heat sink block 5a.

In this embodiment, the heat sink block 5a extends through the insulative substrate 3a, and is partly exposed from the package 1a. Thus, the heat capacity can sufficiently be increased as compared with the mount 5 (Fig. 4). Thus, heat generated by the semiconductor laser chip 4 can efficiently be absorbed and dissipated in this embodiment. Therefore, a relatively high capacity chip can be employed as the semiconductor laser chip 4.

<u>Fourth embodiment</u>

Fig. 7 is a vertical sectional view of a light emitting device according to a fourth embodiment of the present invention.

As shown, a package 1b includes a side wall portion 2a and an insulative substrate 3a. The insulative substrate 3a includes metal interconnection patterns 8b, 9b. A semiconductor laser chip 4a is disposed on a metal heat sink block 5b which extends through the insulative substrate 3a. The side wall portion 2a has a concave interior surface, on which a fluorescent layer 6b is provided. The side wall portion 2a has a side opening, which is closed by a light transmissive protective plate 7a. In

this embodiment, the chip 4a is adapted to emit a laser beam L3 from one of two laser beam emitting ends, which has an increased laser beam emission rate.

Therefore, the chip 4a is inclined by the heat sink block 5b so that the laser beam L3 emitted from the laser beam emitting end is efficiently projected on the fluorescent layer 6b.

The metal interconnection patterns 8b are 9b are connected to n- and p-electrodes of the chip 4a via fine metal wires 11a and 11b, respectively.

The chip 4a is a laser chip adapted to emit a laser beam having the same wavelength as that of the laser beams emitted from the chip 4 in the first embodiment. The fluorescent layer 6b, the side wall portion 2b, the protective plate 7a and the fine metal wires 11a, 11b are composed of the same materials as in the first embodiment.

When a predetermined driving voltage is applied between the interconnection patterns 8b and 9b, the laser beam L3 is emitted from the laser chip 4a. The laser beam L3 impinges on the fluorescent layer 6b to excite the fluorescent layer 6b. Thus, non-coherent white light is generated, and outputted in an arrow direction E from the package 1b.

Non-coherent light of any color may be outputted from the package 1b according to a particular application by properly selecting the wavelength of the laser beam of the chip 4a and the fluorescent material for the fluorescent layer 6b.

Fifth embodiment

Fig. 8 is a top view of a light emitting device according to a fifth embodiment of the present invention, and Fig. 9 is a sectional view of the light emitting device as seen in an arrow direction F-F in Fig. 8.

As shown, a package 1c includes a side wall portion 2c having a top opening and a side opening, and a substrate 3b which closes the side opening. The substrate 3b comprises an insulative substrate having interconnection patterns 8c to 8e and 9c to 9e. Three semiconductor laser chips 4b to 4d are disposed along a vertical line on a metal mount 5c in a generally central portion of the package 1c. The mount 5c extends through the substrate 3b as shown in Fig. 8. The side wall portion 2c has a concave inside shape as seen in section in Fig. 9, and a reflective layer 6c is provided on the interior surface of the side wall portion 2c. The reflective layer 6c is formed in the same manner as the reflective layer 6a in the second embodiment. The chips 4b to 4d each have n- and p-electrodes which are connected to the interconnection pattern 8c to 8e and the interconnection pattern 9c to 9e, respectively, via fine metal wires. The top opening of the side wall portion 2c is closed by a light transmissive protective plate 7b. The semiconductor laser chips 4b to 4d are adapted to emit R(red), G(green) and B(blue) laser beams, respectively.

When a predetermined driving voltage is applied to the chips 4b to 4d between the interconnection patterns 8c to 8e and

9c to 9e, the R, G and B laser beams are emitted from the chips 4b to 4d, and irregularly reflected on the reflective layer 6c thereby to be converted into non-coherent light beams with uneven phases. The non-coherent R, G and B light beams are mixed to provide white light, which is outputted through the protective plate 7b from the package 1c.

According to the present invention, the coherence of the laser beam emitted from the semiconductor laser chip is reduced by the coherence reducing member in the package, and the lower coherence light is outputted from the package. Therefore, the light emitting device is safe for human eyes.